AGATES

THE following letter was addressed by the writer in 1871 to Mr. Joseph John Murphy, and though not originally intended for publication, is now published with the writer's consent :—

St. Andrews, November 4, 1871

DEAR SIR,—I have on my return found your note as to agates. Though I have been at work on the subject in different ways for many years, I have not found myself in a position yet to publish. In fact I cannot yet say that I *know* much as to how they have been formed, though I do know, or rather am able to show, that they have not been made in the manner usually supposed.

The late Principal Forbes conceived that they had been formed by concentric deposition round a central nucleus :—this I showed him to be untenable. Others conceive that siliceous matter in a state of fusion has been poured into cavities through an opening, such opening being called the "point of infiltration." I am able to show that this so-called point of infiltration is an orifice of escape or exit of something.

Fully to state how (from examination of their mode of occurrence, experiments upon the decomposibility of trap rocks under the action of carbonated water, section of agates in every conceivable direction, experiments upon their powers of absorbing liquids, and from microscopic examination) I conceive agates to be formed would call for indeed a long statement.

I will attempt briefly to put it thus :—

Igneous rocks are being poured forth from a volcanic vent, in perfectly fluid or at least plastic flow ; some are dense, some scoriaceous, some frothing, and so when solidified are vesicular, or perchance even hold in suspension bubbles of included water, this latter holding in solution (red-hot solution) solids afterwards to separate as rheolites. Should the air-bubbles of the vesicular rocks arise through the plastic mass while it is motionless, these bubbles will be more or less rounded or pear-shaped. Should the solidifying rock, however, become crystalline or porphyritic, as generally is the case with amygdaloids, the separating crystals of labradorite, &c., will more or less roughen the sides, and so destroy the smooth and rounded figure of the cavity ; while, if the lava-flow continues its motion while the bubbles are still rising, their shape will be more or less flattened or altered :—try bubbles in flowing treacle.

Stage the first.—An empty cavity of any shape.

Stage the second.—The rock, while solidifying, may contain an excess of a magnesian mineral, which is exuded into the cavity ; or this excess of magnesian compound (magnesia not being, to any large extent, a *natural* constituent of the mass of a trap) may be held as vapour in the cavity, to be, on cooling, deposited on its sides. This forms in Scotland, Faroe, Iceland, &c., the layer of celadonite or delessite ; at Giant's Causeway, of chlorophœite, which, on the extraction of the afterwards filled-up cavity, forms the "skin of the pebble."

Stage the third.—One of two processes, the first very doubtful.

The cooling and shrinking rock holds in a state of *liquidity, from heat,* an excess of colloidal silica which is exuded into the cavity forming a chalcedonic druse. But, admitting the process, it must here stop, and a *solid* agate could not thus be formed. This seems to have been the view of Sir George Mackenzie.

The other process I pin my faith to. The thoroughly solidified—indeed the now *old*—rock is having its felspar (labradorite or other) decomposed by water holding carbonic acid in solution. I have proved that this process is rapid and continuous, and agate-holding traps are all rotten ; the colloidal silica, with a certain quantity of *tridamyte* is taken up by this water, and transfuses into the cavity; the silica is there solidified—probably the layer of delessite is the coagulation. We have now a cavity slightly lined with chalcedonic matter, containing, within, water more or less pure, while without (that is outside of the now double skin, delessite and first layer) we have a strong solution of colloidal silica constantly supplied. Endosmose and exosmose are set up with all their resistless force. The *strong* solution finds its way through the two or any number of increasing skins : the *weak* water is forced out through the "point of infiltration," and so in its passage out thins all the successively deposited layers *at that place.* By this continuous flow of colloidal silica (held in solution by liquid) through the already coagulated or deposited layers, continuous coagulation of the silica in the yet hollow agate, and continuous extrusion of the residual water, we have the ultimate filling up of the cavity, and a solid agate formed.

The adhesion of agates to the containing rock is slight in most cases from the so-called "skin" being magnesian and soapy.

The "point of infiltration," instead of being at once filled up, as would result from the inflow of coagulable silica, is in reality the last point filled up, being truly the point of escape : indeed it frequently is not altogether filled up, *remaining an open tube.*

The microscope shows on a cross section the concentric layers of coagulated silica, soluble in alkalies ; the crystals or fibres of *tridamyte* cross these layers at right angles, radiating like a rheolite from the skin, and it is always along the sides of these crystals that intruding and staining liquids find a way ; probably, therefore, along their sides also did the ingress of chalcedonic fluid find entrance. I remain very truly yours,

M. FORSTER HEDDLE

THE ORIGIN OF THE SCENERY OF THE BRITISH ISLANDS[1]

THE Lakes of Britain present us with some of the most interesting problems in our topography. It is obvious that the existence of abundant lakes in the more northern and more rocky parts of the country points to the operation of some cause which, in producing them, acted independently of and even in some measure antagonistically to the present system of superficial erosion. It is likewise evident that as the lakes are everywhere being rapidly filled up by the daily action of wind, vegetation, rain, and streamlets, they must be of geologically recent origin, and that the lake-forming process, whatever it was, must have attained a remarkable maximum of activity at a comparatively recent geological epoch. Hardly any satisfactory trace is to be found of lakes older than the present series ; perhaps Lough Neagh, which from its thick deposits and their fossils, has been referred back to Pliocene times, is the solitary exception. How then have our lakes arisen ? Several processes have been concerned in their formation. Some have resulted from the solution of rock-salt or of calcareous rocks and a consequent depression of the surface. The "meres" of Cheshire, and many tarns or pools in limestone districts, are examples of this mode of origin. Others are a consequence of the irregular deposit of superficial accumulations. Thus, landslips have occasionally intercepted the drainage and formed lakes. Storm-beaches, thrown up by the waves along the sea-margin, have now and then ponded back the waters of an inland valley or recess. The various glacial deposits—boulder-clays, sands, gravels, and moraines—have been thrown down so confusedly on the surface that vast numbers of hollows have thereby been left which, on the exposure of the land to rain, at once became lakes. This has undoubtedly been the origin of a large proportion of the lakes in the lowlands of the north of England, Scotland, and Ireland, though they are rapidly being converted by natural causes into bogs and meadow-land. Underground movements may have originated certain of our lakes, or at least may have fixed the direction in which they have otherwise been produced. A very large number of British lakes lie in basins of hard rock, and have been formed by the erosion and removal of the solid materials that once filled their sites. The only agent known to us by which such erosion could be effected is land-ice. It is a significant fact that our rock-basin lakes occur in districts which can be demonstrated to have been intensely glaciated. The Ice Age was a recent geological episode, and this so far confirms the conclusion already enforced, that the cause which produced the lakes must have been in operation recently, and has now ceased. We must bear in mind, however, that it is probably not necessary to suppose that land-ice excavated our deepest lake-basins out of solid rock. A terrestrial surface of crystalline rock, long exposed to the atmosphere, or covered with vegetation and humus, may be so deeply corroded as, for two or three hundred feet downward, to be converted into mere loose detritus, through which the harder undecomposed veins and ribs still run. Such is the case in Brazil, and such may have been also the case in some glaciated regions before the glaciers settled down upon them. This superficial corrosion, as shown by Pumpelly, may have been very unequal, so that when the decomposed material was removed, numerous hollows would be revealed. The ice may thus have had much of its work already done for it, and would be mainly employed in clearing out the

[1] Abstract of fourth lecture given at the Royal Institution, February 26, by Archibald Geikie, F.R.S., Director-General of the Geological Survey of the United Kingdom. Continued from p. 397.

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